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Patent- og Varemærkestyrelsen
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LED SYSTEM FOR PRODUCING LIGHT

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a system of light-emitting diodes (LEDs) for producing light. By the use of different control strategies the colour of the light produced, the luminous intensity and the luminous efficacy of the light produced may be controlled.

BACKGROUND OF THE INVENTION

US 6,234,645 describes a system comprising at least four light-emitting diodes for the production of white light. The colour rendering index is above 60 and the luminous efficacy is preferably above 30 lm/W. In one embodiment, the colour temperature of the light can be adjusted by selectively switching the light-emitting diodes.

US 5,783,909 describes a system for maintaining the luminous intensity of the light from at least one light-emitting diode. The system comprises a power supply electrically connected to the light-emitting diode for supplying pulses of electrical energy to this light-emitting diode. By adjusting the electrical energy supplied the luminous intensity of the light-emitting diode can be maintained at a pre-selected level, thereby compensating for the diminution of the output due to e.g. temperature variations or ageing.

US 6,012,291 describes a system for temperature control of an optical semiconductor device, e.g. a light-emitting diode. By attaching the semiconductor device to a thermal conductor the temperature of this optical semiconductor device is kept at a constant temperature level despite any influence of the ambient temperature, heat sources etc.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a system capable of controlling the light emitting diodes and thus of the light being emitted from such a system, and which control enables adjustment of more than just one parameter in order to optimise the system. It is also an object of the present invention to provide an apparatus for emitting light by using LEDs, and where the lifetime of the LEDs and the luminous intensity may be increased.

This object may be obtained by a method comprising controlling at least two of the following parameters: the luminous intensity of each of the light emitting diodes, the colour of each of the light being emitted from each of the light emitting diodes, the temperature of each of the light emitting diodes, the temperature of surrounding to the

system, the luminous efficacy of each of the light emitting diodes, the amperage of the electrical power being supplied to the light emitting diodes, the voltage of the electrical power being applied the light emitting diodes and a pulse width applied to the electrical power being applied each of the light emitting diodes.

The object may be obtained by a system comprising means for measuring the luminous intensity of light being emitted from said system, and said system further comprising means for controlling the luminous intensity of each of the light-emitting diodes separately.

The object of the invention may also be obtained by a system comprising means for measuring the luminous intensity of light being emitted from the system, and said system further comprising means for controlling the luminous efficacy of each of the light emitting diodes separately.

The object of the invention may even also be obtained by a system comprising means for controlling the luminous efficacy of each of the light-emitting diodes separately, and said system further comprising means for controlling the luminous efficacy of the system.

The object of the invention may even also be obtained by a system comprising means for measuring the temperature of said light emitting diodes, and said system further comprising means for controlling the temperature of said light emitting diodes.

The object of the invention may even also be obtained by a system comprising means for measuring the electrical power applied light emitting diodes, and said system further comprising means for controlling the electrical power applied to said light emitting diodes.

A system according to the invention may comprise one or more of the following elements: control means for controlling the luminous intensity of the light emitting diodes, control means for controlling the colour of each of the light being emitted from each of the light emitting diodes, control means for controlling the temperature of each of the light emitting diodes and control means for controlling the luminous efficacy of each of the light emitting diodes and control means for controlling the pulse of the electrical power being supplied to each of the light emitting diodes.

Controlling the luminous intensity establishes a means for controlling the sharpness of a colour in question in relation to more or less complementary colours to the colour in question. The luminous efficacy is preferably controlled by controlling each of at least three

and preferably at the most five individual light emitting diodes. The at least three light emitting diodes is capable of emitting light being blue, green and red, respectively.

Controlling the colour of each of the light emitting diodes establishes a means for controlling the overall colour being emitted from the system, i.e. controlling the colour compared to a colouring scheme such as the Theory of Colour from 1810 by Johann Wolfgang von Goethe. The colour is preferably controlled by controlling the colour of each of at least three and preferably at the most five individual light emitting diodes. The at least three light emitting diodes is capable of emitting light being blue, green and red, respectively.

Controlling the temperature, either of each of the light emitting diodes or commonly of all of the light emitting diodes, establishes a means for controlling the luminous intensity being emitted from the system, i.e. controlling the lumen of each of the light emitting diodes. The temperature is preferably controlled by controlling the colour of each of at least three and preferably at the most five individual light emitting diodes. The at least three light emitting diodes is capable of emitting light being blue, green and red, respectively.

Controlling the luminous efficacy of each of the light emitting diodes, establishes a means for controlling the capacity of light being emitted from the system, i.e. controlling the effectiveness, that is the lumen per Watt, of each of the light emitting diodes. The luminous efficacy is preferably controlled by controlling the colour of each of at least three and preferably at the most five individual light emitting diodes. The at least three light emitting diodes is capable of emitting light being blue, green and red, respectively.

Controlling the electrical power being supplied to each of the light emitting diodes, establishes a means for controlling the lifetime of the system and/or of the light emitting diodes, i.e. controlling the duration of light emitting diodes given certain criteria such as colour, intensity, output and/or efficacy of the light being emitted by each of the light emitting diodes. The electrical power is either controlled by controlling the amplitude of the electrical power, i.e. either the amperage or the voltage of the electrical power, or by controlling the pulse of the electrical power, i.e. the frequency of the electrical power.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawing, where
fig. 1 shows a casing for an embodiment of an apparatus according to the invention
fig. 2 shows an array of Light Emitting Diodes constituting part of the apparatus, and

fig. 3 shows a Light Emitting Diode constituting part of the array of these diodes, and fig. 4 shows a cooling unit constituting part of the apparatus.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 shows a housing 1 for a system for illumination by means of light emitting diodes (LEDs). The housing consists of a box containing different elements for illumination. Firstly, an electrical and electronic element 2 is provided at the left side of the housing, said element controlling the emission of light from the LEDs. An insulation 3 is provided within the housing, and a number of other element are provided within the insulation.

An array 4 of LEDs 5 is provided at the right side of the housing. Also, a cooling element is provided centrally in the insulation 3 with a cool side of the cooling element 6 having contact to the gas contained within the interior of the insulation. Light emitted from the LEDS is directed from the array to the left and towards a central line A of the housing. In a focal point 7 of the light emitted from the LEDs, a reflector 8 such as a mirror is provided. The light emitted from the LEDs is directed along the central line A of the housing through a central hole 9 in the array 4, through a hole 10 in the insulation 3 and through a lens 11 in the housing 1 and out of the housing. In the embodiment shown, the lens 11 is a divergent concave lens. However, the lens could also be a convex lens for collecting the light, if the light after having been reflected by the reflector is not precisely focused by the reflector. Apart from the elements mentioned, also a thermal element (see fig. 4) is assigned to the housing, however, preferably provided on the outer side of the housing.

Fig. 2 shows a possible embodiment of an array 4 of LEDs 5, said array 4 suited for a housing 1 having a square cross-sectional area. The LEDs 5 are provided around the central hole 9, and the different LEDs 5 have different colours so that different colours are possible to emit from the system. Preferably, the LEDs 5 have the colour of either red, blue, green and amber for thereby providing the possibility of producing white light. The differently coloured LEDs 5 are provided symmetrically on each side of a vertical symmetry line B or on each side of a horizontal symmetry line C through the central hole 9. Alternatively, the differently coloured LEDS are provided symmetrically on each side of both a vertical symmetry line B and a horizontal symmetry line C.

In fig. 1 and in fig. 2 both the reflector and the array of LEDs are shown as being planar. However, in an alternative and preferred embodiment, the array of LEDs is curved with a concavity directed towards the reflector. As shown in fig. 1, the LEDs have to be diverted towards the reflector by bending the legs of the LEDs. This may induce a risk of breaking

the legs of the LEDs. It will also be difficult to bend the LEGs in the correct angle so that each LED is directed accurately toward the focal point of the reflector.

Also, in an alternative and preferred embodiment, the reflector is slightly curved with a concavity directed towards a focal point of the reflector. Although the intention is that the LEDs all are directed towards the focal point, then it must be remembered that the LEDs emit light along a certain angular extension, perhaps 12° as shown in fig. 3. This results in that also light outside the focal point will be emitted. In order to collect the beams of light emitted from one focal point, the reflector may have a parabolic curvature for focussing the light at the lens before the light is emitted trough the lens.

Preferably, both the array of LEDs and the reflector are curved as explained above so that a synergetic effect is obtained: Both the effect of the LEDs being directed towards the focal point of the reflector without having to bend the legs of the LEDs, and the effect of the reflector collecting the light being emitted from the LEDs before transmitting the light to the lens and through the lens.

Fig. 3 shows an LED 5 as commonly known. The LED is powered by a voltage of 12 V at an amperage of 25-40 mA, The current is applied to the LED by being directed firstly through a resistor 12 and subsequently through the coloured glazing 13 of the LED and thus resulting in light being emitted. In the embodiment shown, the LED 5 emits light under an angle α of 12°. Other types of LEDs are possible to use according to the application and use of the system, i.e. according to the colour of the light intended for being emitted and according to the luminous intensity and the luminous efficacy intended for being emitted from the housing.

Fig. 4 shows schematically a cooling element 6 for cooling a gas contained within the insulation 3 in the housing 1. In the embodiment shown, the cooling element is a Peltier-element of commonly known type. The Peltier-element cools the gas within the insulation in the housing by having the cool side 14 of the Peltier-element provided at the inner side of the housing, and the Peltier-element emits the heat generated during cooling to the outside surroundings of the housing by having the hot side 15 at the outer side of the housing. As shown also in fig. 1, the Peltier-element is provided at the one side of the housing and constitutes part of the housing wall. Preferably, the hot side 15 of the Peltier-element is provided with cooling fins for invcreasing the colling of the hot side by the surroundings. The hot side 15 of the Peltier-element will in special applications such as out-door lighting be directed downwards so that possible water from snow melting will not gather on the hot side and possibly limit the possibility of the surroundings of cooling the hot side of the Peltier-element, but water will drip off the hot side of the Peltier-element.

Apart from the elements shown, the apparatus is preferably also provided with means (not shown) for establishing a vacuum inside the housing. The means for establishing the vacuum may be any exteriorly applied means capable of establishing a vacuum sufficient to provide a vacuum of a certain chosen magnitude depending on the application and use of the apparatus.

In the following, the interaction between the different elements will be described.

The electrical and electronic element is intended for controlling the LEDs. Control of the LEDs comprise control of the electrical current applied the LEDs, control of which of the LEDs that are to be lit, control of at which moment of time each of the LEDs is to be lit and control of which periods of time each of the LEDs is to be lit. Possibly, the control of the moment of time and the period of time each of the LEDs is lit may establish an on/off pulsation applied to the LEDs.

The resistor, which constitutes part of the LED (see fig. 3), is preferably situated together with the electronic element. The resistor produces heat, and it is not desirable to having the heat being emitted within the insulation, because the gas contained within the insulation is subjected to cooling. Heat from the resistors will contravene such cooling.

The insulation is intended for insulating the gas within the insulation towards any heat transfer from the outside surroundings of the housing. The insulation may be any kind of insulation suited for the purpose, depending on the application and use of the apparatus and depending on the outer surroundings of the housing. Thus, the insulation may be polystyrene, it may be any insulation material such as the commonly known insulation wool materials based on rock or based on glass, it may be other materials suited for insulation purposes and capable of assisting in a maintaining of a certain temperature within the insulation in the housing despite the risk or possibility of possible heat transfer from the outer surroundings of the housing due to a temperature difference.

The cooling element, in the embodiment shown the Peltier-element, is, as mentioned, intended for cooling the gas within the insulation of the housing. Cooling of the gas may take place by cooling the gas to a temperature as low as -50°C. Preferably the temperature of the gas contained within the insulation is between 20°C and -50°C, most preferred between 0°C and -20°C, depending on the application and use of the system.

The means for establishing the vacuum is intended for subjecting the gas contained within the insulation to vacuum or perhaps subjecting the gas contained within the entire housing

to vacuum. The pressure, to which the gas contained within the insulation may be lowered, is as low as between 1000 N/m^2 and 2000 N/m^2, i.e. between 1/10 and 1/5 of normal atmospheric pressure. Perhaps the pressure of the gas within the housing is between 2000 N/m^2 and 5000 N/m^2, i.e. between 1/5 and 1/2 of normal atmospheric pressure. In some circumstances, it will be possible to obtain a pressure as low as 250 N/m^2. This corresponds to the pressure in an atmospheric altitude of about 8,000 m. At such an altitude the temperature may be as low as about -30°C.

The gas within the housing, and especially within the insulation, taking the basis of ideal physical conditions within the housing, is subject to the equation of state, saying:

$$p \cdot V = n \cdot R \cdot T$$

where p is the pressure of the gas contained in the housing or within the insulation, V is the volume of the gas contained within the housing or within the insulation, n is the amount of moles in the gas in the housing or within the insulation, R is the gas constant, i.e. 8.31 J/(mole · K), and T is the temperature of the gas contained within the insulation.

Thus, if the volume of the housing or the volume within the insulation is constant, and R is per definition constant, then, if the pressure p is decreased by the exteriorly applied vacuum means, then the amount of moles is decreased correspondingly. However, an advantage is obtained, when initially subjecting the gas to a vacuum. If the temperature after having been subjected to a vacuum, is decreased, then the amount of moles to be cooled is much less, and thus the amount of energy for cooling the gas contained within the insulation is decreased accordingly.

Given a desire or a need to decrease the temperature to a certain low level, then the amount of electrical energy to be used for driving the Peltier-element is less than if the gas contained within the insulation is not subjected to vacuum initial to cooling the gas. Alternatively, given a certain amount of electrical energy available to drive the Peltier-element, then the low temperature, which it may be desirable of needed to reach, will be lower than if the gas is not subjected to vacuum initially to cooling the gas.

However, depending on the low temperature, which it is desirable or needed to be reach, then the initial subjection of vacuum to the gas contained within the insulation may be suspended with. This may be the case, if the gas contained within the insulation has a low specific heat, or if the temperature of the atmosphere surrounding the housing is sufficiently low, perhaps during a winter season, compared to the temperature needed.

Other ways of controlling the LEDs will hereafter be described. Basis is taken in that the speed of light in vacuum is approximately 300.000 km/s. The LEDs may be subjected to an on/off pulsation in order to increase the luminous intensity of the light being emitted. This pulsation may preferably be effected as a square wave pulsation, where a certain current is applied to individually chosen LEDs of the array of LEDs, where said current is maintained at a certain level for a certain amount of time, and where the current is cut off subsequent to the certain amount of time, thereby resulting in an extinguishing of the LED.

Most preferred, the square wave pulsation is applied so that an overlap between applied currents to the individual LEDs is obtained. Thus, just before the applied current at a certain level is cut off for one LED, then the next LED to be subjected to the current is being applied the current. Thus, an overlap is established between the cut-off of the current of one LED and the application of current to another LED. This overlap reduces the risk of the total array of LEDs emitting a flickering light. This could however be the case due to a possible delay between the cut-off of current to one LED, thereby extinguishing the LED, and before another LED is applied current for that other LED to emit light corresponding to the light just having been emitted previously by the one LED.

Another way of controlling the light emitted from the LED may be to subject the LEDs to an ever increasing level of current along with the lifetime of the LEDs running out. It is commonly known that the luminous intensity of LEDs decrease gradually during their lifetime. This may be dealt with by increasing the current applied to the LEDs in order to constantly, during the lifetime of the LEDs, maintaining a luminous intensity of 100%.

This may however decrease the lifetime of the LEDs compared to not increasing the current during their lifetime, because of the fact that the lifetime of the LEDs also depends on the level of current applied to the LEDs. Thus, if the current is constantly increased, the lifetime of the LEDs will be reduced. Alternatively to maintaining a luminous intensity of 100% during the entire lifetime of the LEDs, a lower luminous intensity may be the limit desirable to maintain, however, the limit still being greater than the limit possible to obtain, if the current applied is not increased during the lifetime of the LEDs.

The system may be used in many applications for many different uses. Major application may be outdoor lighting, show-lights and central domestic or office lighting, where a number of centrally installed systems according to the invention is used to supply light to a plurality of locations by transmitting the light along fibre-optical cables.

CLAIMS

1. A method for controlling light being emitted from a light emitting system comprising at least three light emitting diodes, said method comprising controlling at least two of the following parameters: the luminous intensity of each of the light emitting diodes, the colour of each of the light being emitted from each of the light emitting diodes, the temperature of each of the light emitting diodes, the temperature of surrounding to the system, the luminous efficacy of each of the light emitting diodes, the amperage of the electrical power being supplied to the light emitting diodes, the voltage of the electrical power being supplied to the light emitting diodes and a pulse width applied to the electrical power being supplied to each of the light emitting diodes.

2. A system comprising at least three light-emitting diodes, preferably at the most five light emitting diodes, for producing light, wherein the diodes are capable of emitting light at different wavelengths; a first diode capable of emitting light in the range of 430 nm to 490 nm (blue), a second diode capable of emitting light in the rage of 530 nm to 565 nm (green), and a third diode capable of emitting light in the range of 605 nm to 630 nm (red) and said system comprising means for measuring the luminous intensity of light being emitted from said system, and said system further comprising means for controlling the luminous intensity of each of the light-emitting diodes separately.

3. A light-emitting diode system according to claim 2, wherein said measuring means is adapted for sending an intensity signal to the controlling means, said signal intended for being used in the control of the luminous intensity of the light being emitted from the system by controlling the luminous intensity of each of the light-emitting diodes.

4. A light-emitting diode system according to claim 2 or claim 3, wherein said system further comprises means for determining the colour of the light being emitted from the overall system comprising a plurality of light emitting diodes, alternatively for determining separately the colour of the light being emitted from each of the light emitting diodes.

5. A light-emitting diode system according to claim 4, wherein said determining means is adapted for sending a colour signal to the controlling means, said signal intended for being used for controlling the colour of the light being emitted from the system.

6. A light-emitting diode system according to any of the claims 2-5, wherein the colour of the light being emitted from said system is adjustable between infrared (IR) light and ultraviolet (UV) light by controlling each of the light emitting diodes by said controlling means.

7. A light-emitting diode system comprising at least three light-emitting diodes, preferably at the most five light emitting diodes, for producing light, wherein the diodes are capable of emitting light at different wavelengths; a first diode emitting light in the range of 430 nm to 490 nm (blue), a second diode emitting light in the rage of 530 nm to 565 nm (green), and a third diode emitting light in the range of 605 nm to 630 nm (red), and said system further comprising means for measuring the luminous intensity of light being emitted from the system, and said system further comprising means for controlling the luminous efficacy of each of the light emitting diodes separately.

8. A light-emitting diode system according to claim 7, wherein the controlling means is a power supply, and wherein luminous intensity of the system is controlled by said power supply by adjusting the one or more of the parameters amperage, voltage or frequency of the electrical power supplied.

9. A light-emitting diode system according to claim 7 or claim 8, wherein the controlling means is a power supply, and wherein luminous intensity of the system is controlled by said power supply by introducing a square wave pulse to the electrical power supplied.

10. A light-emitting diode system according to any of claims 7-9, wherein said system further comprises means for determining the colour of the light being emitted from the overall system comprising a plurality of light emitting diodes, alternatively for determining separately the colour of the light being emitted from each of the light emitting diodes.

11. A light-emitting diode system according to claim 10, wherein said determining means is adapted for sending a colour signal to the controlling means, said signal intended for being used for controlling the colour of the light being emitted from the system.

12. A light-emitting diode system according to any of the claims 7-11, wherein the colour of the light being emitted from said system is adjustable between infrared (IR) light and ultraviolet (UV) light by controlling each of the light emitting diodes by said controlling means.

13. A system comprising at least three light-emitting diodes, preferably at the most five light emitting diodes, for producing light, wherein the diodes are capable of emitting light at different wavelengths; a first diode capable of emitting light in the range of 430 nm to 490 nm (blue), a second diode capable of emitting light in the rage of 530 nm to 565 nm (green), and a third diode capable of emitting light in the range of 605 nm to 630 nm (red), and said system further comprising means for controlling the luminous efficacy of

each of the light-emitting diodes separately, and said system further comprising means for controlling the luminous efficacy of the overall system comprising a plurality of light emitting diodes.

14. A light-emitting diode system according to claim 13, wherein the controlling means is a power supply, and wherein luminous intensity of the system is controlled by said power supply by adjusting the one or more of the parameters amperage, voltage or frequency of the electrical power supplied.

15. A light-emitting diode system according to claim 13 or claim 14, wherein the controlling means is a power supply, and wherein luminous intensity of the system is controlled by said power supply by introducing a pulse width to the electrical power supplied.

16. A light-emitting diode system according to any of claims 13-15, wherein said system further comprises means for determining the colour of the light being emitted from the system, alternatively for determining separately the colour of the light being emitted from each of the light emitting diodes.

17. A light-emitting diode system according to claim 16, wherein said determining means is adapted for sending a colour signal to the controlling means, said signal intended for being used for controlling the colour of the light being emitted from the system.

18. A light-emitting diode system according to any of the claims 13-17, wherein the colour of the light being emitted from said system is adjustable between infrared (IR) light and ultraviolet (UV) light by controlling each of the light emitting diodes by said controlling means.

19. A system comprising at least three light-emitting diodes, preferably at the most five light emitting diodes, for producing light, wherein the diodes are capable of emitting light at different wavelengths; a first diode capable of emitting light in the range of 430 nm to 490 nm (blue), a second diode capable of emitting light in the rage of 530 nm to 565 nm (green), and a third diode capable of emitting light in the range of 605 nm to 630 nm (red) and said system comprising means for measuring the temperature of said light emitting diodes, and said system further comprising means for controlling the temperature of said light emitting diodes.

20. A light-emitting diode system according to claim 19, wherein said measuring means is adapted for sending a temperature signal to the controlling means, said signal intended for

being used in the control of the temperature of each of the light emitting diodes separately.

21. A light-emitting diode system according to claim 19 or claim 20, wherein the temperature controlling means is capable of controlling the temperature of the light emitting diodes in the range of -60°C to +50°C, preferable in the range of -40°C to +35°C.

22. A light emitting diode system according to nay of claims 8-10, wherein said system also comprises means for measuring the temperature of surroundings of the system.

23. A light-emitting diode system according to any of claims 19-21, wherein said system further comprises means for determining the colour of the light being emitted from the system, alternatively for determining separately the colour of the light being emitted from each of the light emitting diodes.

24. A light-emitting diode system according to claim 23, wherein said determining means is adapted for sending a colour signal to the controlling means, said signal intended for being used for controlling the colour of the light being emitted from the system.

25. A light-emitting diode system according to any of the claims 19-24, wherein the colour of the light being emitted from said system is adjustable between infrared (IR) light and ultraviolet (UV) light by controlling each of the light emitting diodes by said controlling means.

26. A system comprising at least three light-emitting diodes, preferably at the most five light emitting diodes, for producing light, wherein the diodes are capable of emitting light at different wavelengths; a first diode capable of emitting light in the range of 430 nm to 490 nm (blue), a second diode capable of emitting light in the rage of 530 nm to 565 nm (green), and a third diode capable of emitting light in the range of 605 nm to 630 nm (red) and said system comprising means for measuring the electrical power applied to the light emitting diodes, and said system further comprising means for controlling the electrical power applied to said light emitting diodes.

27. A light-emitting diode system according to claim 26, wherein the electrical power applying means is capable of controlling the applying a current as a square wave current, preferably a square wave current establishing overlap between a current being applied initially to one light emitting diode and a current being applied subsequently to another light emitting diode.

28. A light-emitting diode system according to claim 26 or claim 27, wherein said system further comprises means for determining the colour of the light being emitted from the overall system comprising a plurality of light emitting diodes, alternatively for determining separately the colour of the light being emitted from each of the light emitting diodes.

29. A light-emitting diode system according to claim 28, wherein said determining means is adapted for sending a colour signal to the controlling means, said signal intended for being used for controlling the colour of the light being emitted from the system.

30. A light-emitting diode system according to any of the claims 26-29, wherein the colour of the light being emitted from said system is adjustable between infrared (IR) light and ultraviolet (UV) light by controlling each of the light emitting diodes by said controlling means.

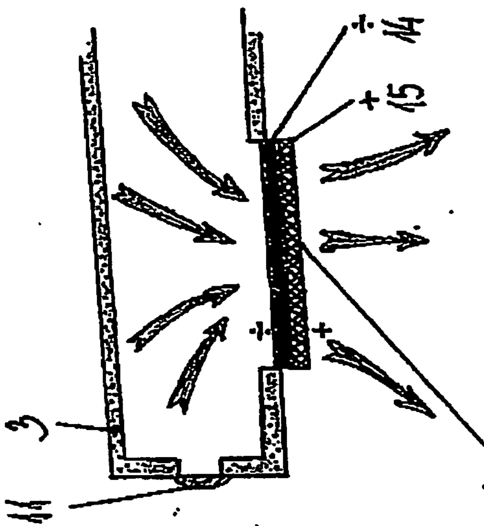

FIG. 4

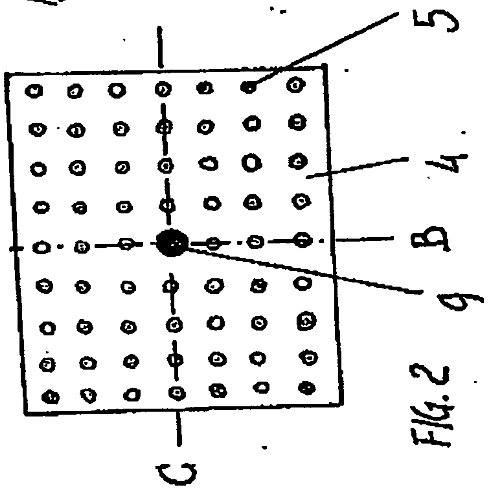

FIG. 2

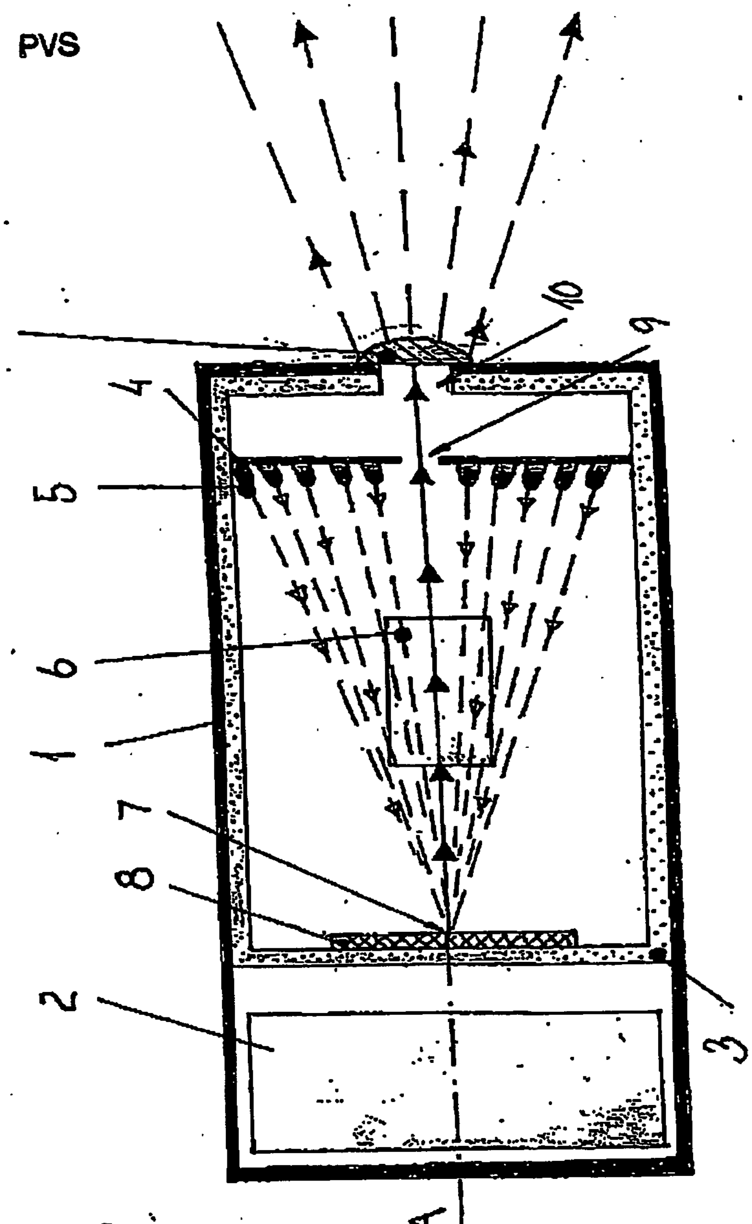

FIG. 1

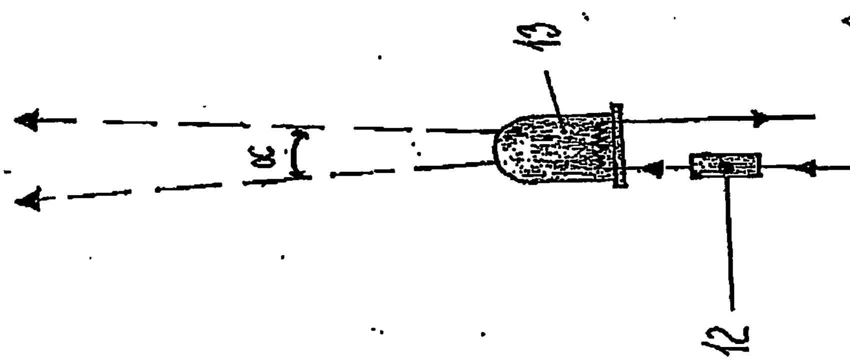

FIG. 3